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Study on the Carbon Footprint of Schools in Pokhara, Nepal

Sandesh Adhikari and Rajib Pokhrel*

School of Engineering, Faculty of Science and Technology, Pokhara University, Pokhara, Nepal

* Author to whom correspondence should be addressed; E-Mail: *rajibp@pu.edu.np*

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Abstract

Academic institutions are significant contributors to carbon emissions due to large student populations, high energy use, waste generation, and extensive transportation demands. This study estimated the Carbon Footprint (CF) of eight public and private schools in Pokhara Metropolitan City (PMC) using the GHG Protocol across three scopes: (1) emissions from school buses and fuels, (2) electricity consumption, and (3) emissions from staff and student vehicles, waste, canteen fuels, textbooks, and paper. Schools with over 1,000 students were sampled through purposive and random sampling, ensuring representation of both public and private institutions. Data were collected using questionnaires, interviews, and school records, while students' bag weights were measured to calculate Scope 3 emissions from textbooks and copies. Emissions were calculated as Metric Tons of CO_2 equivalent ($MTCO_2e$) using activity data and Emission Factors. The total CF was 409.76 $MTCO_2e$/year, averaging 51.22 $MTCO_2e$/year (76.25 for private schools, 26.19 for public). Scope 1, Scope 2, and Scope 3 emissions contributed 227.86, 5.1, and 176.8 $MTCO_2e$, respectively. The per capita CF ranged from 0.011 to 0.055 $MTCO_2e$/year, averaging 0.029 $MTCO_2e$/year. This study offers critical insights into reducing GHG emissions, promoting sustainable development, and creating carbon-neutral academic institutions.

Keywords

Greenhouse Gases, School, Carbon Footprint, GHG Protocol, Emission Factor

1. Introduction

Global warming and its impact have been a crucial issue in Himalayan country Nepal. Government of Nepal put this agenda strongly in the COP 29 meeting too, when carbon emission and its management were discussed rigorously. Schools play a fundamental role in sustainability, promoters of innovation, science, and technology. Therefore, every day more schools are joining to fight against global warming. One of the contributions of schools is the carbon footprint (CF). Schools are rarely seen as an enemy of the environment in Nepal because they are considered a learning place. However, there has not been enough research on the impacts of school in the environment due to the volume of students, usage of transportation and energy systems, wastage etc., at least in Nepal. With its diverse education system, Nepal is an ideal place to study the carbon/ecological footprint of academic institutions. Recognizing and quantifying carbon footprint of these institutions is critical to developing sustainable practices and reducing their environmental impact [1]. Carbon footprint is a method of estimating the total Green House Gas (GHG) emissions of a product in carbon equivalents over its life cycle, from the production of the raw materials used in its manufacture to the disposal of the final product. It is a technique for identifying and

measuring the individual greenhouse gas emissions from each activity within a supply chain process step and the framework for attributing these to each output product [2].

The term "carbon emissions" describes how human activity releases greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4) into the atmosphere. These emissions are mainly generated from the combustion of fossil fuels, including coal, petroleum and natural gases for power generation, transportation, industrial processes, and residential use. Carbon dioxide is the most crucial among the greenhouse gases that is responsible for most of the anthropogenic global warming. Additional greenhouse gases include fluorinated gases, nitrous oxide (N_2O), and methane (CH_4). Hydrofluorocarbons also contribute greatly to carbon emissions. These gases are released by various activities, including agricultural activities, deforestation, waste management and industrial processes [3]. The carbon footprint analysis is a vital pilot study in the area of school's consumption-based foot printing [4]. Schools have played an important role in helping people cope with climate and environmental challenges through international initiatives such as the Green Deal and Climate Action Plan Security, which focus on climate neutrality. Schools, as establishments dedicated to teaching, are crucial in enabling pupils to take part in steady development of care and should be role models for themselves, students and staff, and the community. Therefore, the first step in becoming a sustainable organization is figuring out, monitoring, and disclosing personal Carbon Footprint (CF) [5].

Food waste releases carbon dioxide and other gases during decomposition. Methane, a strong greenhouse gas, is produced when food waste breaks down in landfills. It is released during anaerobic digestion, where oxygen availability is limited. In addition, carbon dioxide is released during the decomposition of organic matter aerobically. This has an impact on climate change and greenhouse gas emissions [6]. When carbon footprint assessments are incorporated into educational institutions, carbon emissions from different aspects of school operations are thoroughly assessed and then reduced. This approach entails the methodical measurement of greenhouse gas emissions associated with various activities conducted in educational institutions, including but not restricted to energy use, waste disposal procedures, transportation networks, and the acquisition of goods and services. Given that schools, like other institutions, contribute significantly to the overall problem of climate change, implementing a carbon footprint measurement system becomes essential to promoting environmental responsibility. By using this method, educational institutions acquire a comprehensive grasp of their ecological footprint, which goes beyond the boundaries of their physical facilities and encompasses the full lifecycle of the goods and services they use. Using the instrument of carbon footprint assessments, schools are able to measure the environmental impact of their internal operations as well as take responsibility for the ecological footprint of the goods and services. In addition to helping schools, understand the implications of their actions for the environment, this proactive involvement positions them as a key player in the global effort to reduce carbon emissions and slow down the rate of climate change [7].

In recent years, most of the schools have their own vehicle to pick up and drop students from their residents to the school therefore most of the major cities including PMC faces traffic jam in the morning at school start time and in the evening at end of school. They emit large volume of carbon emission from transportation facility. Moreover, they generate carbon

emission from different facilities such as canteen, printing and press, heating / cooling, room lighting, etc. Identifying the major carbon emitter and estimation of CF could be helpful for developing the scientific policy in order to shift our academic institution towards the green institution.

2. Methodology

The study was carried out inside Pokhara Metropolitan City, Kaski, Nepal which is one of the major cities of Nepal consisting a total of 33 wards. According to a bulletin published by the Education Department of Pokhara Metro (Department of Education of Pokhara Metropolitan City, 2080 BS), there were altogether 454 schools in Pokhara Metropolitan City, including 207 Public schools and 247 Private Schools. Great variation in the number of students was found among those schools. To portray a notable amount of carbon footprint among educational institutions, population was narrowed down. Schools with the number of students greater than or equal to 1000 were included in this research. Now, the population was narrowed down to 27 and we studied 8 schools (4 private and 4 public) proportionately after analysing factors and indexes for this study. These steps ensured that there were no two schools from the same wards for better comparison among the schools. The following formula as in equation (1) was used to determine the sample school numbers [8]. Figure 1 shows the location of the schools considered in this study whereas Figure 2 presents a detailed flow diagram outlining the research process.

$$n = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+\frac{z^2 \times p(1-p)}{e^2 \times N}} \quad (1)$$

where,

N = Number of population (26)

n = Sample size required

p = Population proportion (taken as 0.04 in this case; 26 schools out of 454)

z = corresponding Z-value for 90 % confidence level; 1.645

e = margin of error = 10 %

2.1 Emissions Resulting from Direct Activities (Scope 1)

Scope 1 covered direct emissions from school buses and other vehicles registered under the school's name, excluding vehicles used by students and staff for commuting. It also included the fuel (petrol and diesel) used by school hostels for cooking, and LPG (Liquefied Petroleum Gas) used in the school laboratory. Data were retrieved from the school records, including fuel and LPG bills. When bills and records were insufficient, information was obtained from the principal, accountant, school bus driver, and chef. For buses and other vehicles, the fuel consumption was measured in litres for a specific period and then converted to annual data. In Nepal, the most commonly used LPG cylinder is 14.2 kg. The volume of gas in a 14.2 kg LPG cylinder is calculated as 14.2 kg / 0.51 kg/L, which equals 27.83 L (using the density of LPG gas at 0.51 kg/L). After determining the number of cylinders used over a certain period

and extrapolating to an annual figure, this number is multiplied by 27.83 to obtain the total LPG consumption for the year.

2.2 Emissions Resulting from Indirect Activities (Scope 2)

Scope 2 covered indirect emissions from the generation and transmission of electricity, labelled as indirect since the electricity is generated outside of the schools. This data was gathered by reviewing school electricity bills and interviewing key personnel. In some cases, only payment records were available. To determine the exact units of electricity consumed, we contacted the Distribution Centres of Nepal Electricity Authority (NEA) according to the school's location. One unit of electricity is equal to 1kWh of energy, and the emission factor is based on the generation of 1kWh of energy. Given Nepal's rich water resources, the energy used is mostly derived from hydropower. We used the emission factor for 1kWh of hydroelectricity, which is significantly more carbon-friendly than other methods of electricity generation.

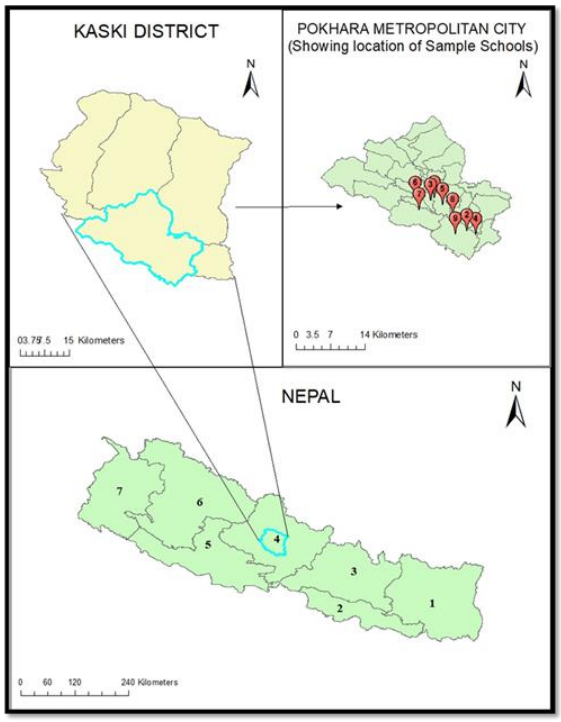

Figure 1: Location of schools considered under this study in different wards of Pokhara Metropolitan City, Nepal.

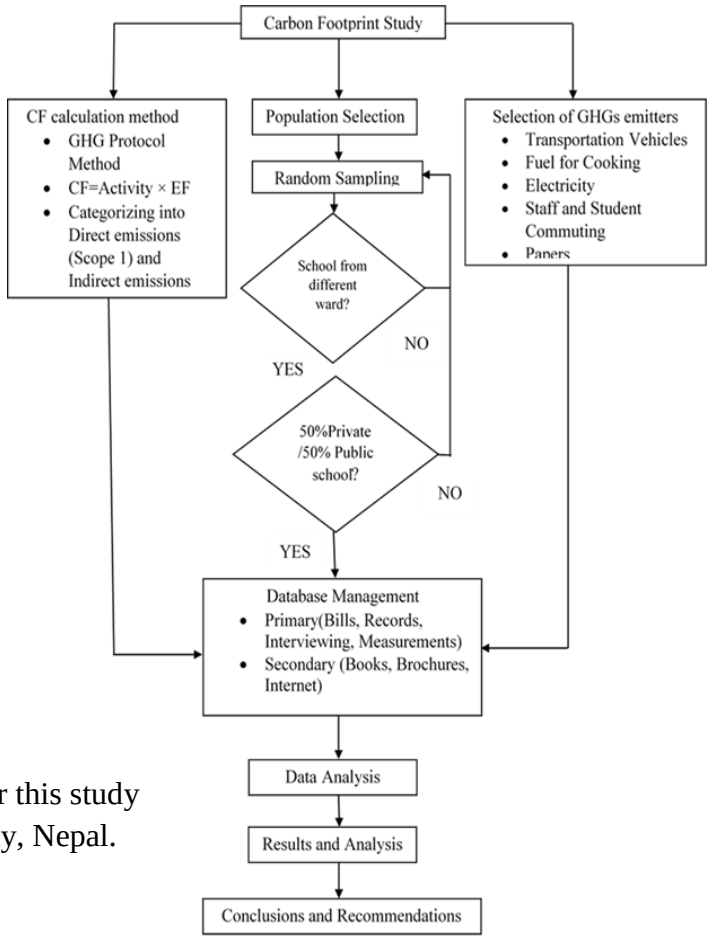

Figure 2: Flow diagram shows the research process.

2.3 Emissions Resulting from Other Indirect Activities (Scope 3)

2.3.1 Staff/Student Commuting

The information was gathered by assessing the number of vehicles and their respective travel distances. Staff and students were interviewed to ascertain their commuting distances to and from school. These distances were then multiplied by the vehicles' fuel efficiencies

to determine petrol and diesel consumption. Fuel efficiency of cars was assumed at 11.8 km/L (0.085 L/km) [9] while motorcycles/scooters were assumed to have an average efficiency of 40 km/L (0.025 L/km) [10]. A comprehensive list of staff was obtained from the school's administration, including their addresses and contact details. Interviews were conducted with staff members, and any missing data were supplemented through consultation with the gatekeeper and other key informants. Additionally, Google Maps was used to validate the distances between their residences and the school.

2.3.2 LPG used in Canteen

The LPG consumption in canteens, not directly owned by the school, was categorized under indirect emissions. The quantity of LPG utilized was determined through purchase records whenever available, and through information provided by Key Informants when such records were not accessible.

2.3.3 Food Waste

The food waste from the canteen was assessed using a portable weighing scale where feasible. In cases where weighing the waste was not possible, interviews were conducted with the canteen chief or relevant personnel. The data collected through both methods were then aggregated for the entire year.

2.3.4 Paper

Schools annually use a substantial amount of paper for printing various documents such as certificates, mark sheets, question papers, and administrative paperwork. In this study, the focus was on A4 (210 mm x 297 mm) sheets weighing 70 grams per square meter (gsm), which are commonly used for printing purposes. In Pokhara Metropolitan City, schools typically conduct four terminal examinations each year, resulting in a peak in paper usage during these periods. Data collection occurred in two phases: i) Regular day-to-day paper usages, and ii) Paper usages during examinations. It is important to note that the printing of answer sheets was excluded from the analysis, as schools typically maintain a stock of these papers. Information was gathered through interviews with key personnel such as accountants and examination coordinators. Data were primarily obtained in terms of reams of paper, with one ream weighing approximately 2.18 kg for 70 gsm paper, containing 500 sheets. The total number of reams was multiplied by 2.18 and converted to tons for the analysis.

2.3.5 Textbooks/Notebooks

Textbooks and notebooks, both made of paper, were individually weighed using a portable digital electronic scale to assess their mass and determine the weight of students' bags. Bags of students from different language mediums (Nepali or English) were weighed separately, as both are common in Nepalese Government schools. The weight of one bag from each class was multiplied by the total number of students in that class to obtain the total bag weight (including textbooks and notebooks). This method, while potentially underestimating bag weight, allowed for the determination of total textbook/notebook weight across all schools, which was then converted into tons. Due to the unavailability of location specific data, the emission factors (EFs) were taken from different literatures as in Table 1 in kgCO_2e per units when emission factor database from IPCC were not available. The results were expressed as MTCO_2e/year, MTCO_2e per person per year - person including students, staff, and employees. It was calculated by using the formulae shown in equation 2 and equation 3:

$$CF\ per\ student = \frac{A}{B} \quad (2)$$

$$CF\ per\ Capita = \frac{A}{B+C} \quad (3)$$

where,
A = Total CF of the school per year
B = Total number of students in the school
C = Total number of staffs in the school

Table 1: Emission factors considered in this study.

Process	EF	Unit	Source
Electricity	0.024	kg CO_2e per kWh	[11]
Petrol Combustion	2.1	kg CO_2e per liter	[12]
Diesel combustion	2.6	kg CO_2e per liter	[12]
LPG combustion	1.41	kg CO_2e per liter	[13]
Paper sheets	1650	kg CO_2e per ton	[14]
Food waste	0.44	kg CO_2e per kg	[15]

3. Results and Discussion

This study analysed the Carbon Footprint of eight schools running inside Pokhara Metropolitan based on the projections of the school opening for 200 days in a year. These schools located in different wards of PMC had varying number of students and varying number of staffs too. These results highlight the dominance of transportation and indirect emissions in the schools' overall carbon footprint. Average CF of the 8 schools to be 51.22 $MTCO_2$e/year. The highest CF was of School 6 with 102.64 $MTCO_2$e/year whereas the least CF was of School 2 with the value of 17.04 $MTCO_2$e/year which is shown in Figure 3. Based on the total value of the CF, it was seen that the private schools had more CF than that of public schools. The research presented that higher number of transportation modes and usage of much more papers including textbooks/notebooks were the main reasons for this.

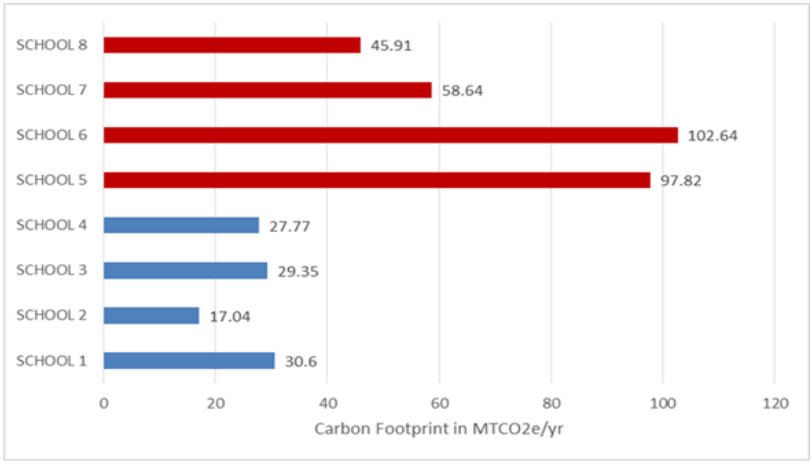

Figure 3: Total CF from different schools.

The total carbon footprint of eight schools was 409.76 $MTCO_2$e, with Scope 1 contributing the most (227.86 $MTCO_2$e, 55.6%), followed by Scope 3 (176.8 $MTCO_2$e, 43.1%) and Scope 2 (5.1 $MTCO_2$e, 1.2%) as demonstrated in Figure 4. The main contributors to the CF were the

transportation sector (54%), papers (27%), staff commute (7%) and canteen fuel (6%) as shown in Figure 5. The contributions from hydroelectricity were low due to low EF of electricity generation from water. Bikes/Scooters for students were not allowed in most of the schools, so student commutes contributed low. Also, the LPGs used in schools were very few in number and hence it contributed to less emission.

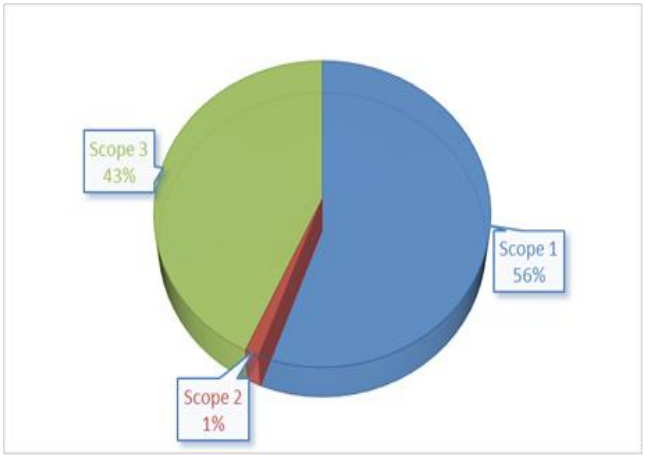

Figure 4: CF contributing from different scopes.

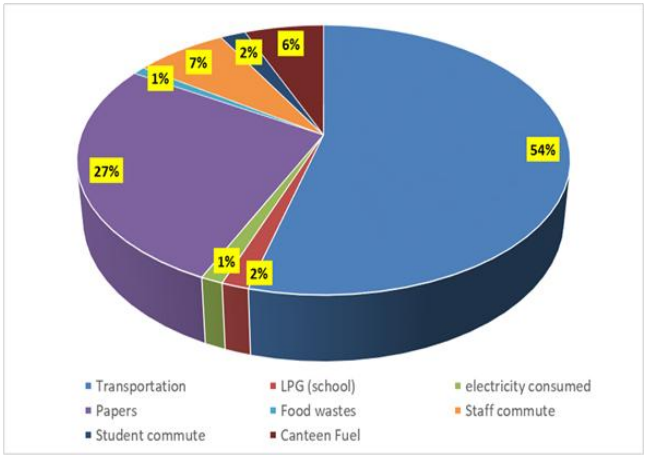

Figure 5: Main GHGs emitting sources in the school.

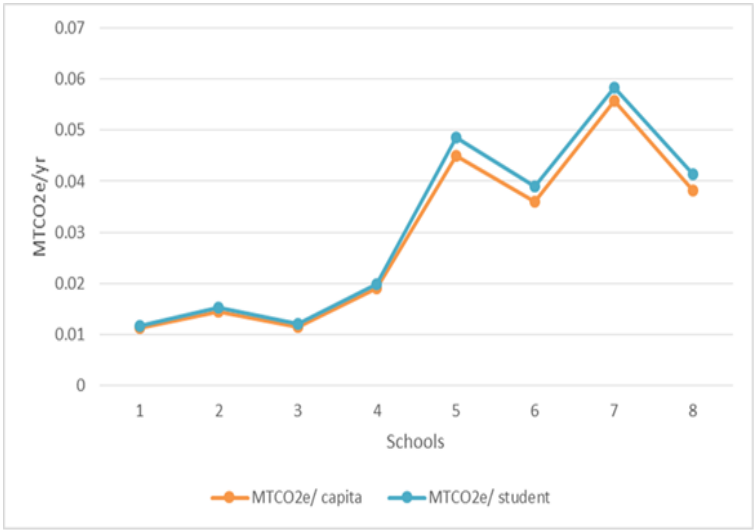

Figure 6: Carbon Footprint per capita and per student from the schools in Pokhara.

CF per student and CF per capita per year of the schools in this study are almost identical to each other as in Figure 6. School 7 has the highest per capita CF of all the schools although it's total CF per year was the third highest among the eight schools. This means that despite having lower number of students, the per person CF was the highest in School 7. School 5 and 6 on the other hand had a relatively low CF per capita and CF per student when compared to School 7. The Carbon Footprint per capita, calculated by dividing total emissions by the combined student and staff populations, ranged from 0.011 to 0.055 $MTCO_2e$ per year. These values are significantly lower compared to global averages reported in studies of similar institutions, likely due to Nepal's reliance on hydropower. Table 2 shows the CF/capita/year from different academic institutions around the world where average CF calculated in this study was corporately low. It shows that Nepalese schools emitted noticeably less GHGs as compared to the academic institutions in the developed country.

Table 2: CF/capita/year of various academic institutes around the world.

S.N.	Institutes	CF/cap/year	Source
1	Average CF of the schools in this study	0.029 $MTCO_2e$	
2	Average CF of four pilot schools in Germany	0.62 $MTCO_2e$	[16]
3	Polytechnic University of Madrid, Spain	1.55 $MTCO_2e$	[17]
4	St. Edward's University, USA	3.7 $MTCO_2e$	[18]
5	Leeds University, UK	2.36 $MTCO_2e$	[19]
6	Talca University, Chile	0.95 $MTCO_2e$	[20]
7	National Autonomous University, Mexico	1.46 $MTCO_2e$	[21]
8	University Technology Malaysia, Malaysia	2.1 $MTCO_2e$	[22]
9	University of Illinois, USA	7.50 $MTCO_2e$	[23]

From this study, it was found out that the vehicles including school buses and staff vehicles were the leading cause of high Carbon Footprint in the schools. If emphasis is given on using electric vehicles and buses for students, then the diesel consumption would be greatly reduced. There were no electric vehicles, (cars/bikes/scooter) in the schools covered in this study; it shows that we are still not taking the GHG emissions and Climate Change Impact seriously. So, staff- being the icon of knowledge should be motivated to ride electric vehicles. This can eventually encourage the students to change their gasoline-based vehicles to electric. And since hydroelectricity has a very low EF, electric vehicles won't add that much CF. An individual e-bike can reduce the average overall CF by 265 $kgCO_2e$/year [24]. Similarly, providing residency (quarter) to the permanent school staffs can also help in reducing the carbon footprint of the schools which arises from their vehicles since they do not have to travel.

If the school's permanent teachers used the school bus rather than using their personal vehicles, the carbon footprint would be greatly reduced. Likewise, for permanent full-time teachers, the school could introduce a staff bus. One or two staff buses instead of numerous personal bikes/scooters/cars would emit lesser carbons. One liter less petrol and diesel combustion will reduce approx. 2.1$kgCO_2e$ and 2.6$kgCO_2e$ of CF respectively.

In the long-term, the schools could encourage cycling from home to schools for staffs/students who are in the periphery of the school. This will not only result in less carbon emissions but also improve the health of the staffs/students. In many of the sample schools here, students were not allowed to bring their personal bikes/scooters/cars in the schools except a few. These should be the case for all the schools inside the Pokhara Metropolitan City [1].

The use of textbooks/ notebooks and printing of papers also had a great contribution to the high Carbon Footprint of schools. Online teaching which was once practiced during the COVID pandemic can also help in reducing the carbon footprint [25]. It can help in reducing the number of textbooks/notebooks required for the students. Likewise, recycling of papers can lead to less use of new A4 papers in the school's administration as well [26]. Afforestation is one of the earliest and well-known methods to promote the health of environment. Planting of trees which can greatly absorb carbon can reduce the carbon footprint [27].

For this, the schools can include "Planting and Gardening" as one of their extra-curricular activities (usually conducted on Fridays in Nepal) at least once a month. Large-scale forest restoration around the world could reduce annual CO_2 emissions by 5.2 Gt (gigatons) by 2030, equivalent to about 11% of current global emissions [28]. Advising students to reduce the waste food/tiffin and encouraging them to bring their own tiffin in their own private lunchboxes can help to minimize the carbon footprint from the canteens. Effective from February, 2021, the government had instructed all public schools across the country not to serve junk food as midday meals to students. This has resulted in less plastic wastes coming from noodles, biscuits etc. Moreover, for the management of wastes, the schools and teachers should demonstrate proper way of Solid Waste Management by Composting and also the encouragement of 3R (Reduce, Reuse and Recycle) methods. Separating wastes in different containers based on their types, teaching students to grow their own foods at homes can be some other ways to reduce the carbon footprint [29]. Even one kg reduction in the food waste generated will reduce 0.44 kgCO_2e of the CF.

4. Conclusions

The Carbon Footprint is the total carbon emissions related to an activity. These emissions arise from many places and organizations. This research focused on finding the Carbon Footprint from schools since they are widely considered as a holy place for studies and rarely considered as a place to threaten the environment. This research showed the total CF of 8 schools randomly selected (with students' number greater than 1000) to be 409.76 MTCO_2e using the GHG Protocol Standard. Based on the GHG Protocol, Scope wise emissions were calculated where Scope 1, Scope 2 and Scope 3 accounted for 56 %, 1% and 43 % of the emissions respectively. The research also showed the CF of private schools to be almost as thrice the CF of the public schools. Main emissions were from the transportation means, and staff commutes. Printing of textbooks and papers also contributed to the emissions significantly. Due to the lack of proper data from the IPCC for Nepal, the emission factors were taken from literature review so, the difference in EF can bring some differences in the estimation of Carbon Footprint. But nonetheless, schools have a major role to reduce their Carbon Footprint. Less use of transportation modes, and papers while focusing on electronic alternatives, afforestation, burning of less fuels can prove beneficial to reduce the CF. In conclusion, schools have a significant responsibility and they could play vital role for the reduction of Carbon Footprint. Moreover, and the outcomes from this study could be helpful for policy maker in order to formulate the scientific policy to shift our academic institution towards the green institution.

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Conflicts of Interest Statement

The authors declare no conflicts of interest for this study.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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